

Sonic Boom Calculations for the N+2 Configuration



Mark D. Sanetrik

NASA Langley Research Center



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Outline



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- Challenges of Sonic Boom Calculations
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 - Effect of Domain Extent
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 - Effect of Static Aeroelastic Deflections
 - Effect of Engines
- Concluding Remarks and Future Work

Introduction



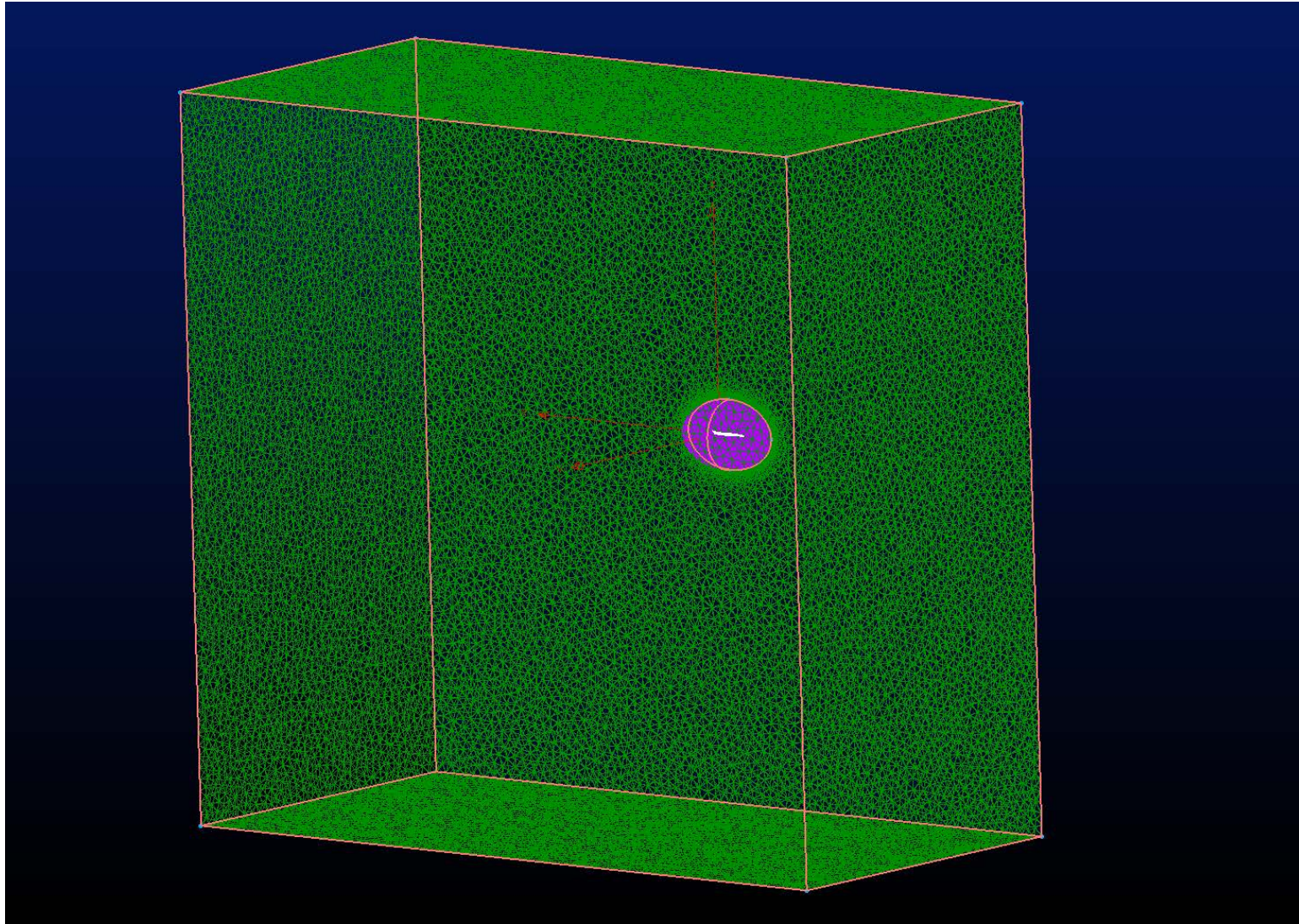
- Low sonic boom flight a major requirement for N+2 Program
- Extensive work done to optimize sonic boom signature
- Optimization done on a rigid structure
- Structure will deflect aeroelastically under aerodynamic loads
- How will static aeroelastic deflections change the sonic boom signature?

Requirements for Sonic Boom Calculations

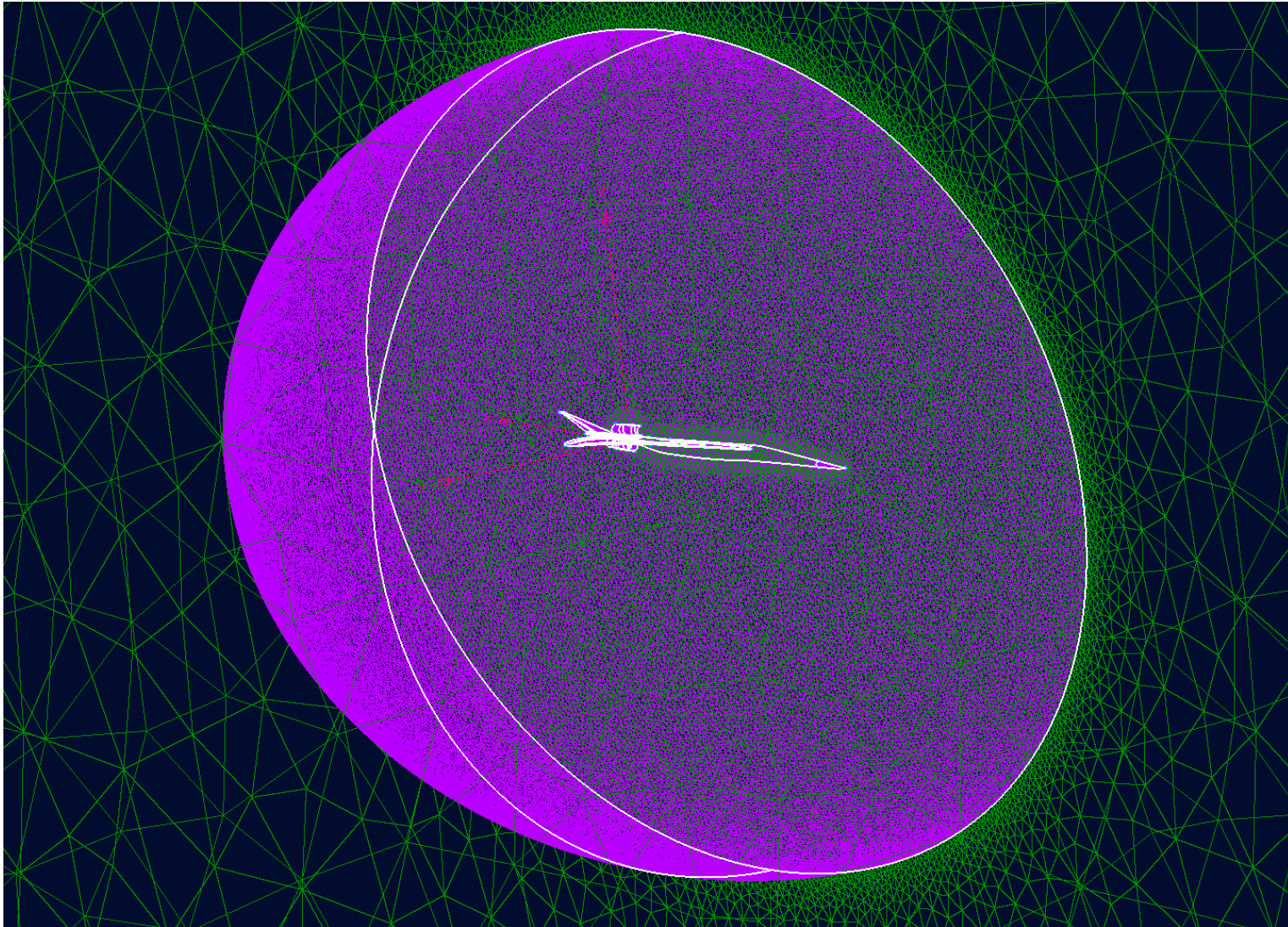


- Conventional Static Aeroelastic domain is rectangular
- Body is defined at 0° angle of attack
- Same grid can be used for multiple flow conditions
- Sonic Boom domain must be shock aligned
- Conical-shaped domain with angle of cone dictated by Mach angle
- Body must be rotated to proper angle of attack
- Separate grid for each flow condition

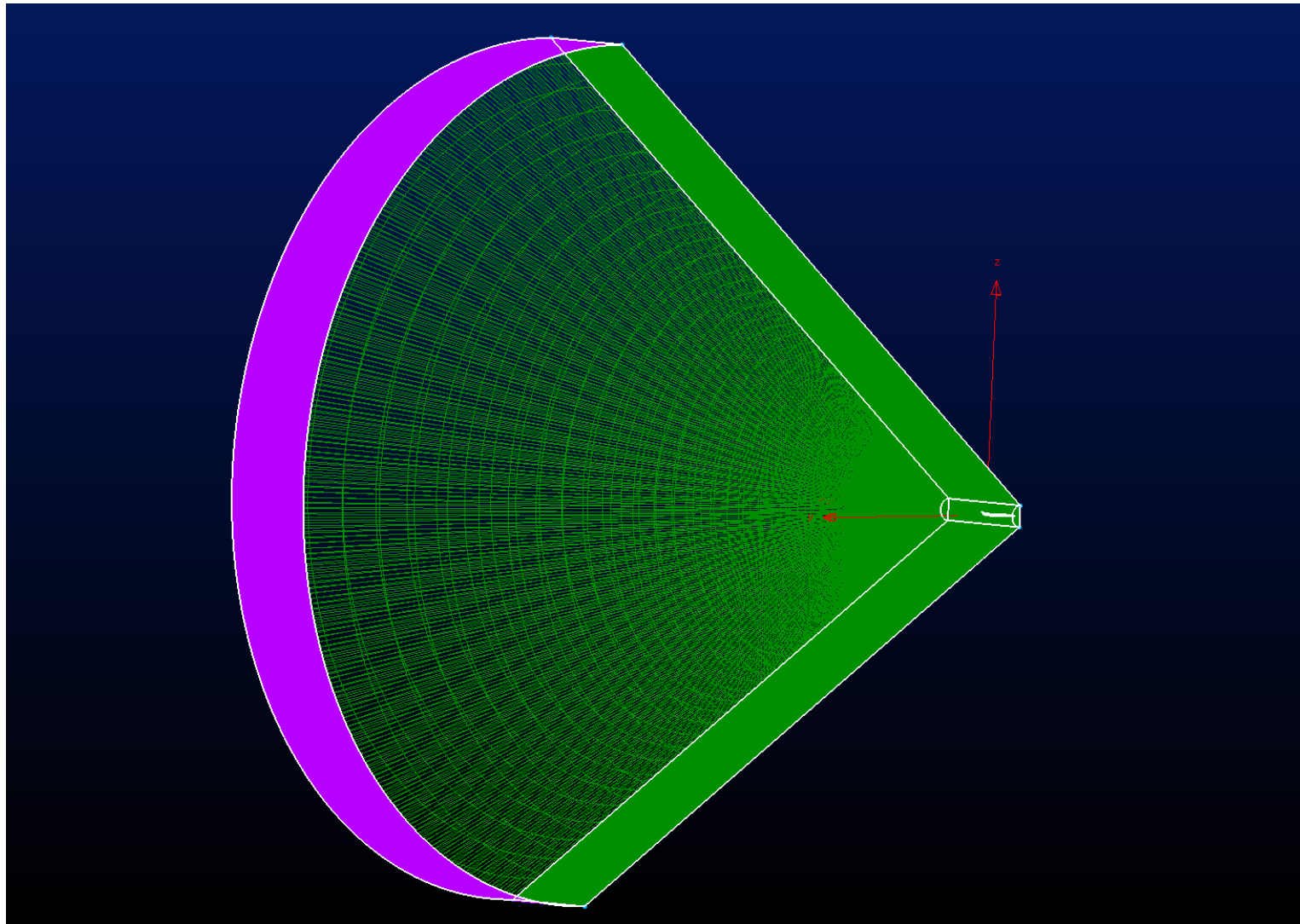
CAE Computational Domain



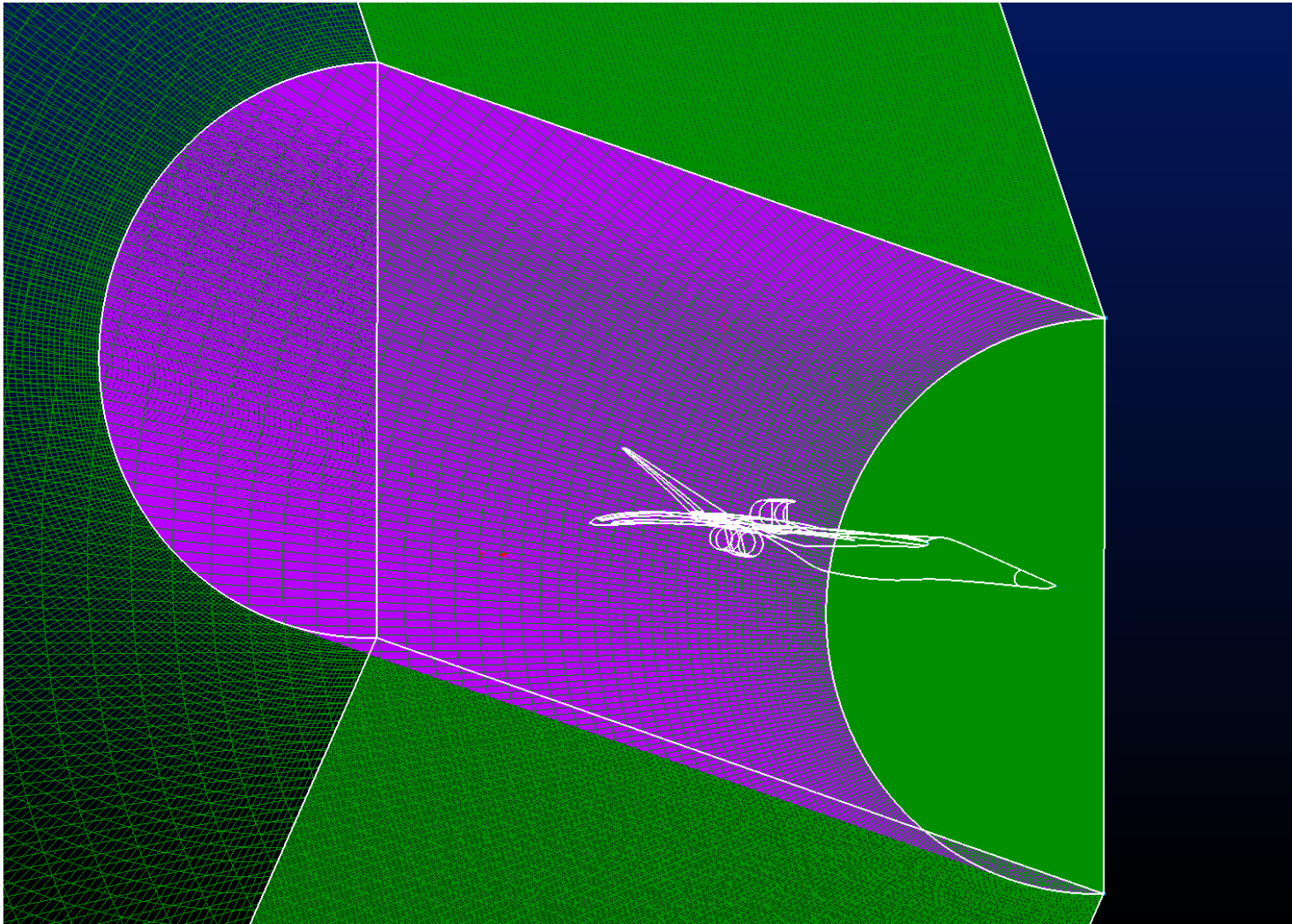
CAE Computational Domain Detail



Sonic Boom Computational Domain



Sonic Boom Computational Domain



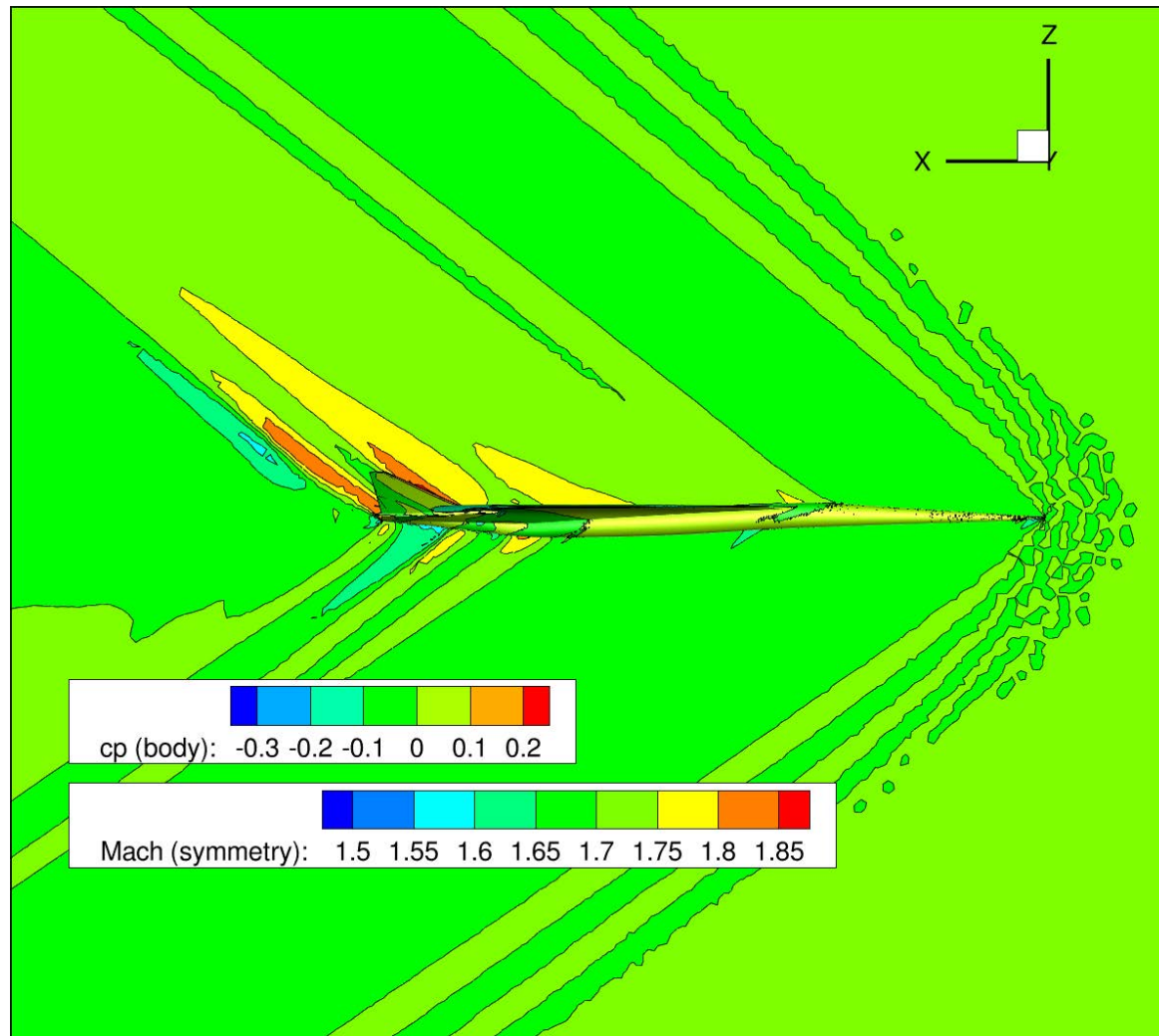
Challenges of Sonic Boom Calculations



- Separate grid for every flow condition
- Extremely fine near-field grid required
- Where to extract pressure signature?
 - Too close and the pressure signature not fully developed
 - Too far away and the pressure signature is dissipated
 - Current practice is 3 body lengths
- Use of external program to propagate shock to ground level (sBOOM)
- Interpretation of ground signatures

Conventional CAE Solution

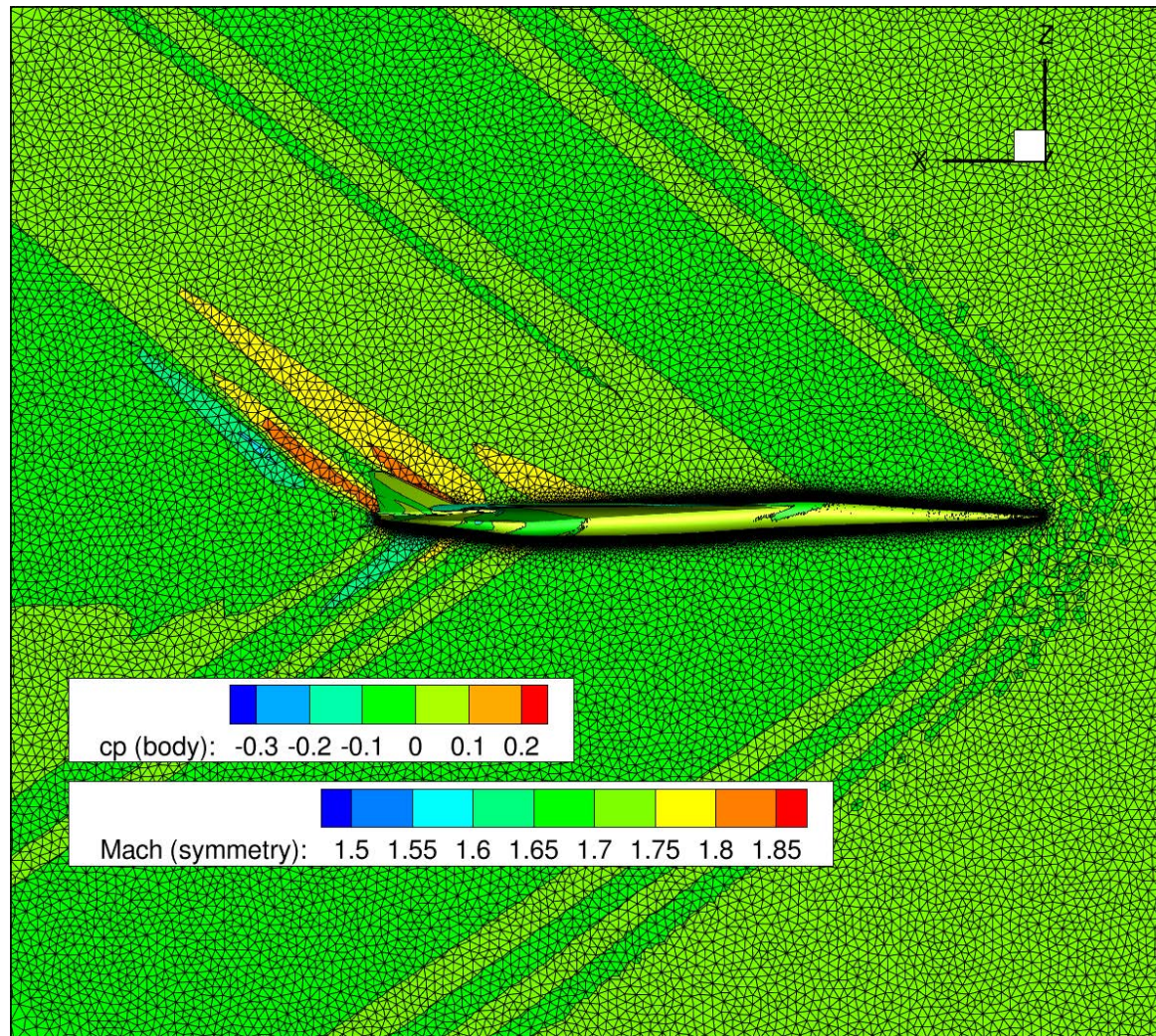
Inviscid, No Engines, Mach = 1.70, $\alpha = 2.25^\circ$



11.8 MGP, $C_L = 0.14343$, $C_D = 0.09220$

Conventional CAE Solution with Grid

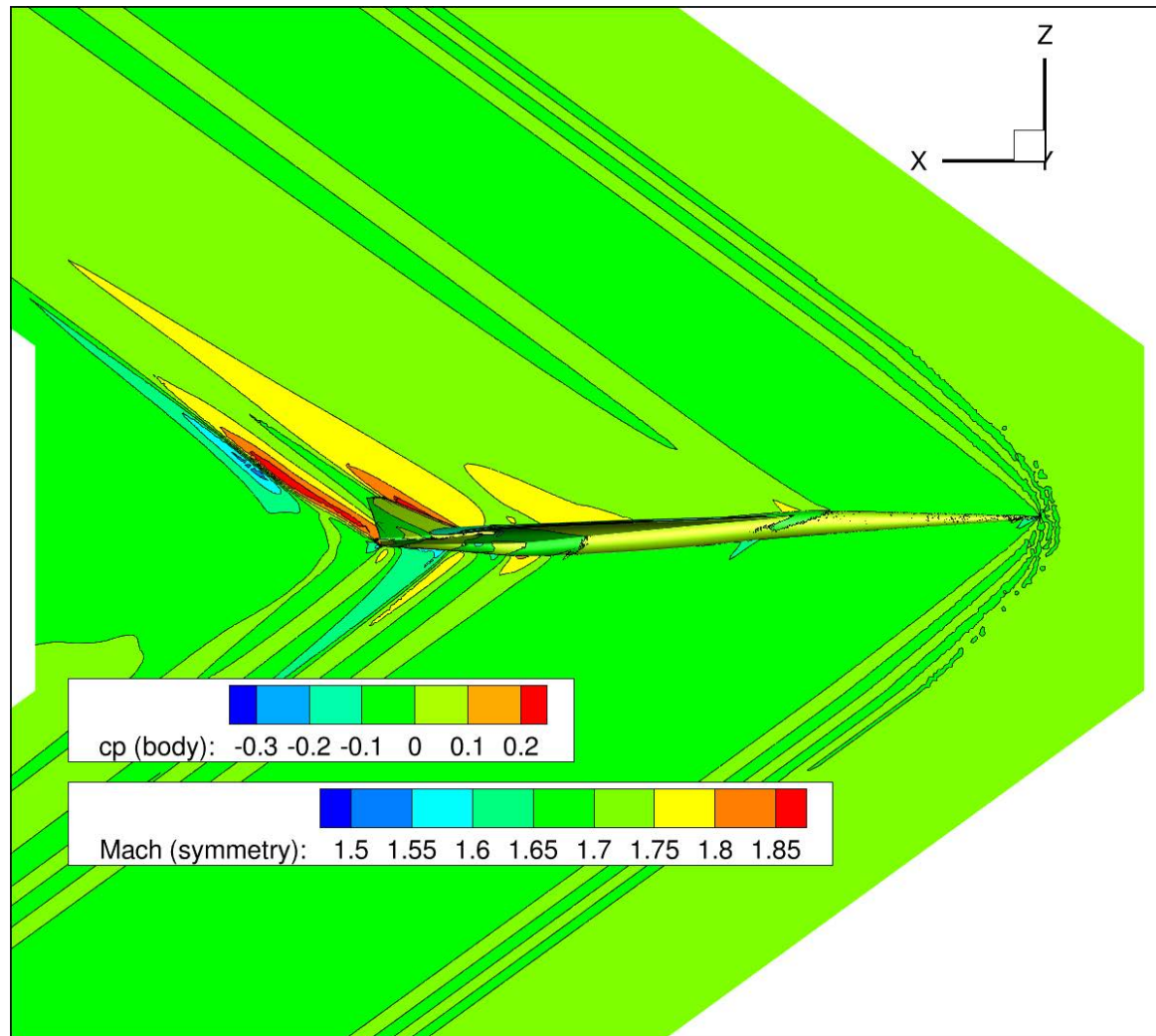
Inviscid, No Engines, Mach = 1.70, $\alpha = 2.25^\circ$



11.8 MGP, $C_L = 0.14343$, $C_D = 0.09220$

Sonic Boom Coarse Solution

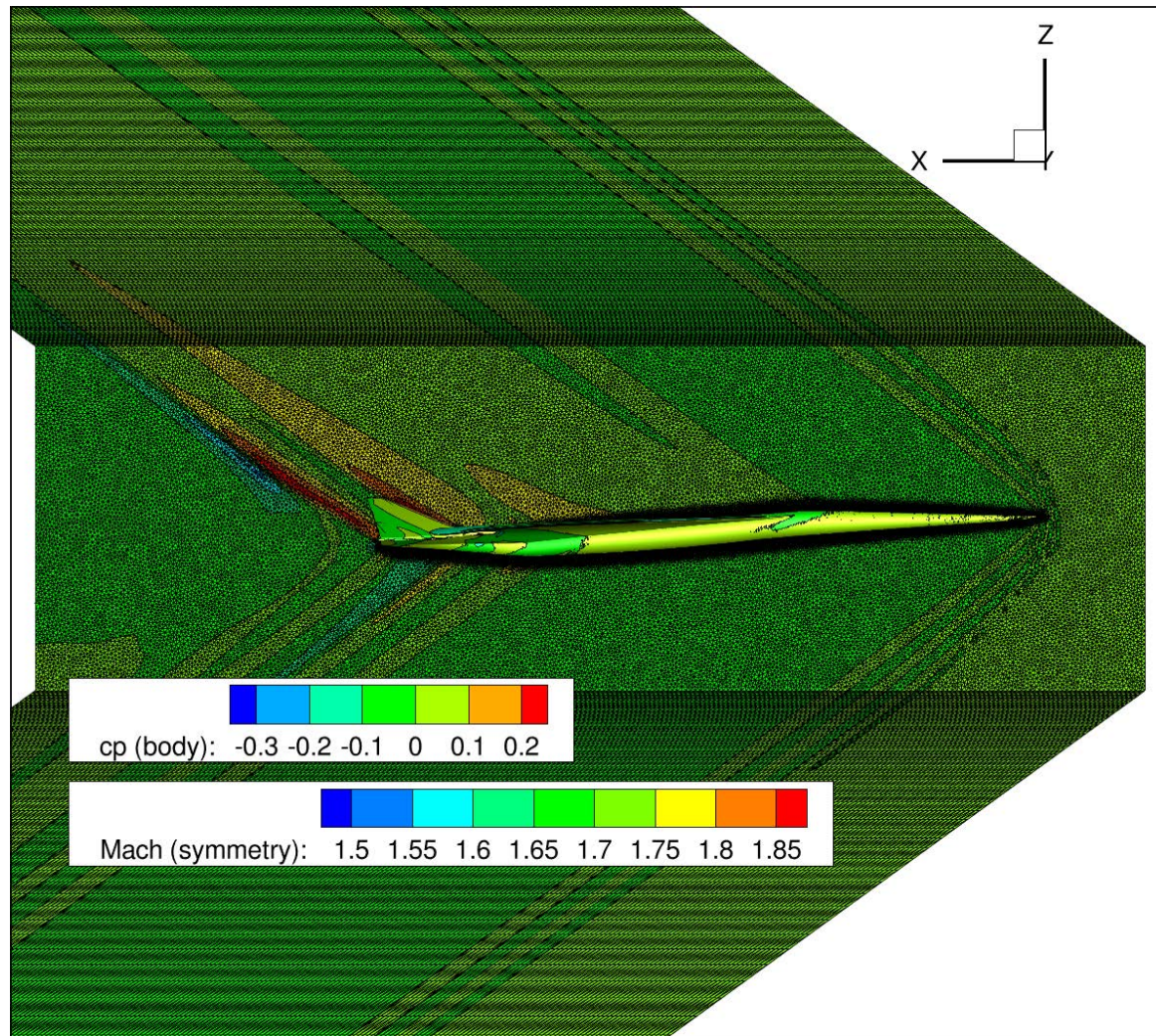
Inviscid, No Engines, Mach = 1.70, $\alpha = 2.25^\circ$



15.9 MGP, $C_L = 0.14342$, $C_D = 0.09252$

Sonic Boom Coarse Solution with Grid

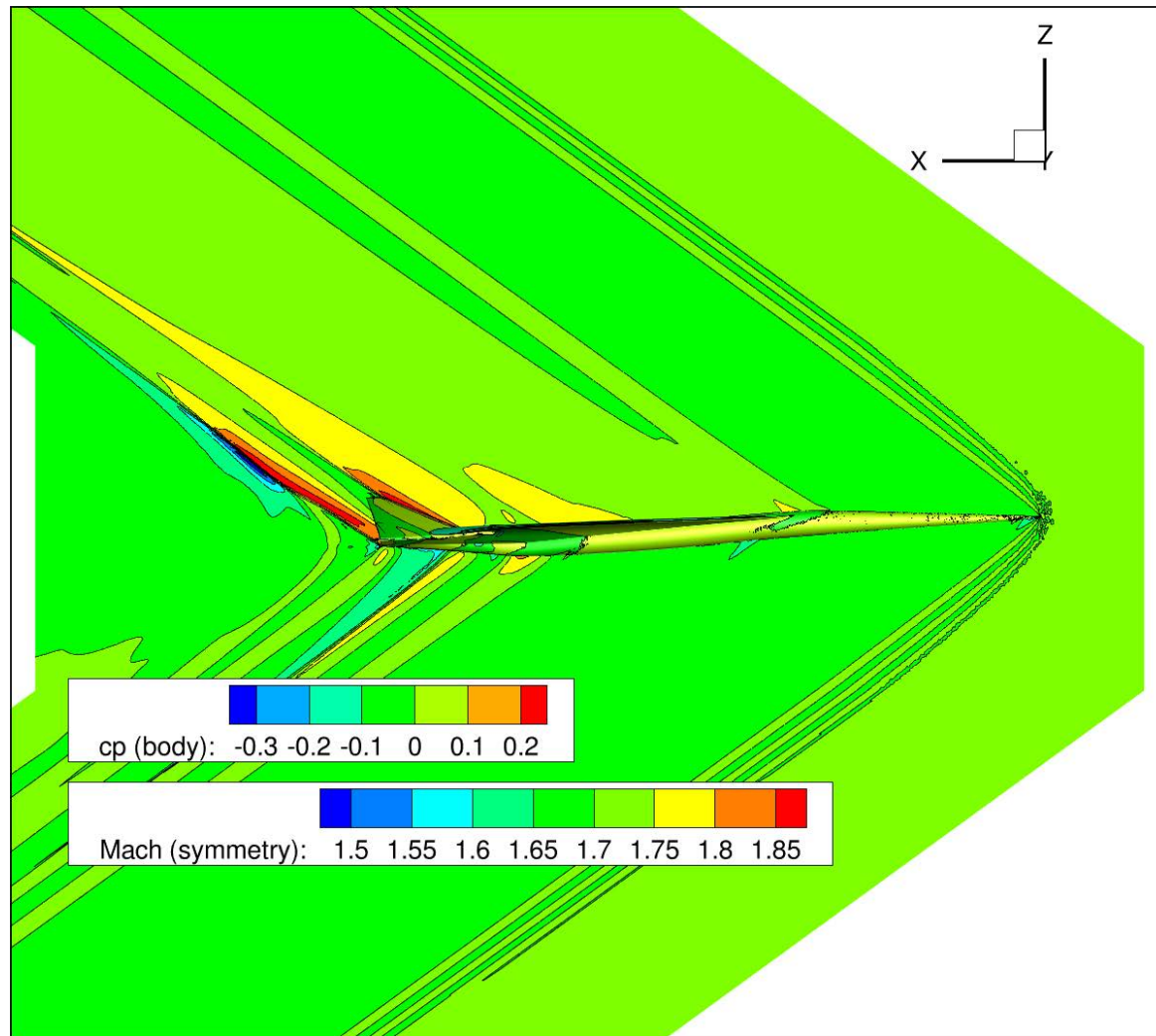
Inviscid, No Engines, Mach = 1.70, $\alpha = 2.25^\circ$



115.9 MGP, $C_L = 0.14342$, $C_D = 0.09252$

Sonic Boom Medium Solution

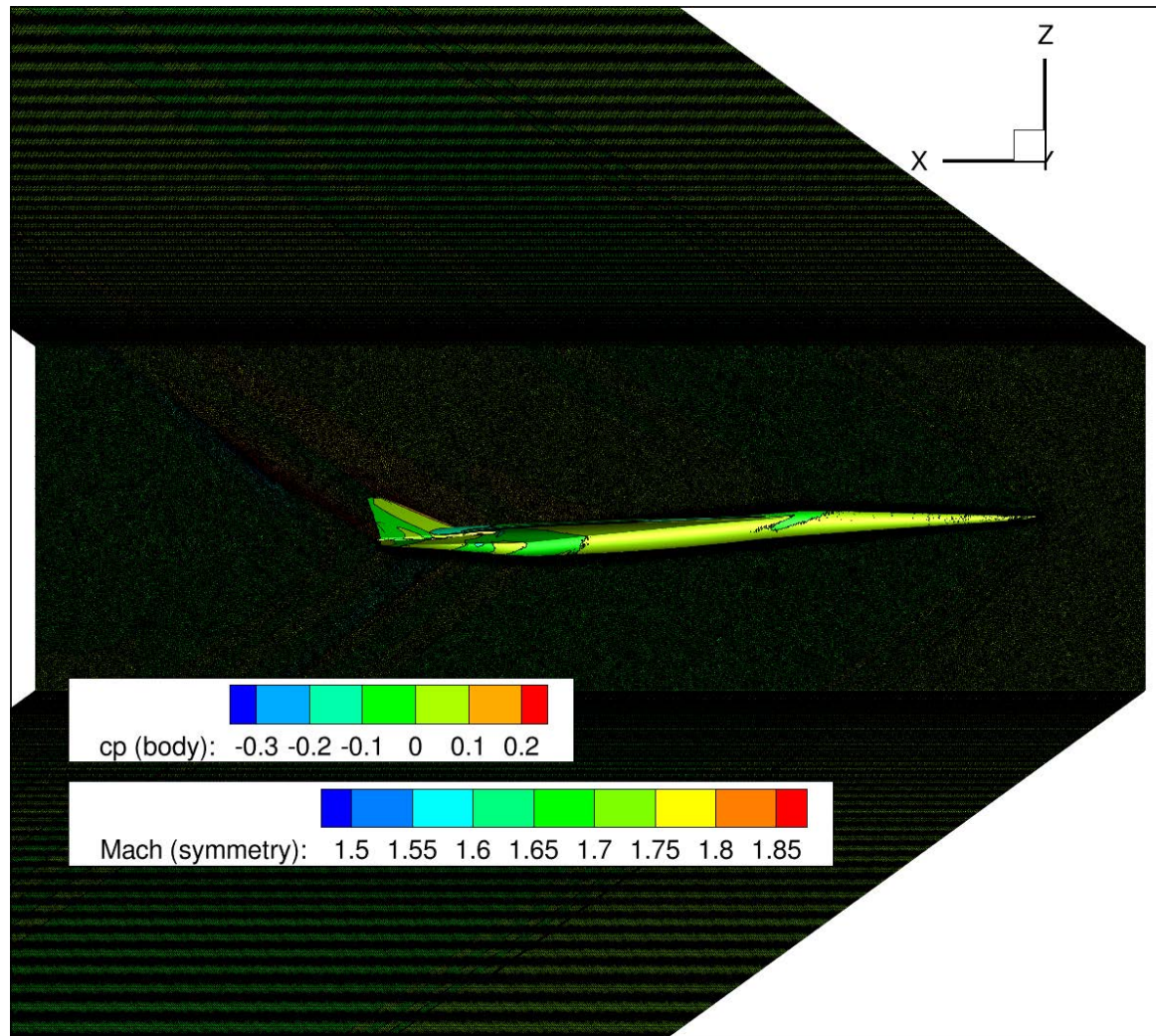
Inviscid, No Engines, Mach = 1.70, $\alpha = 2.25^\circ$



46.5 MGP, $C_L = 0.14343$, $C_D = 0.09251$

Sonic Boom Medium Solution with Grid

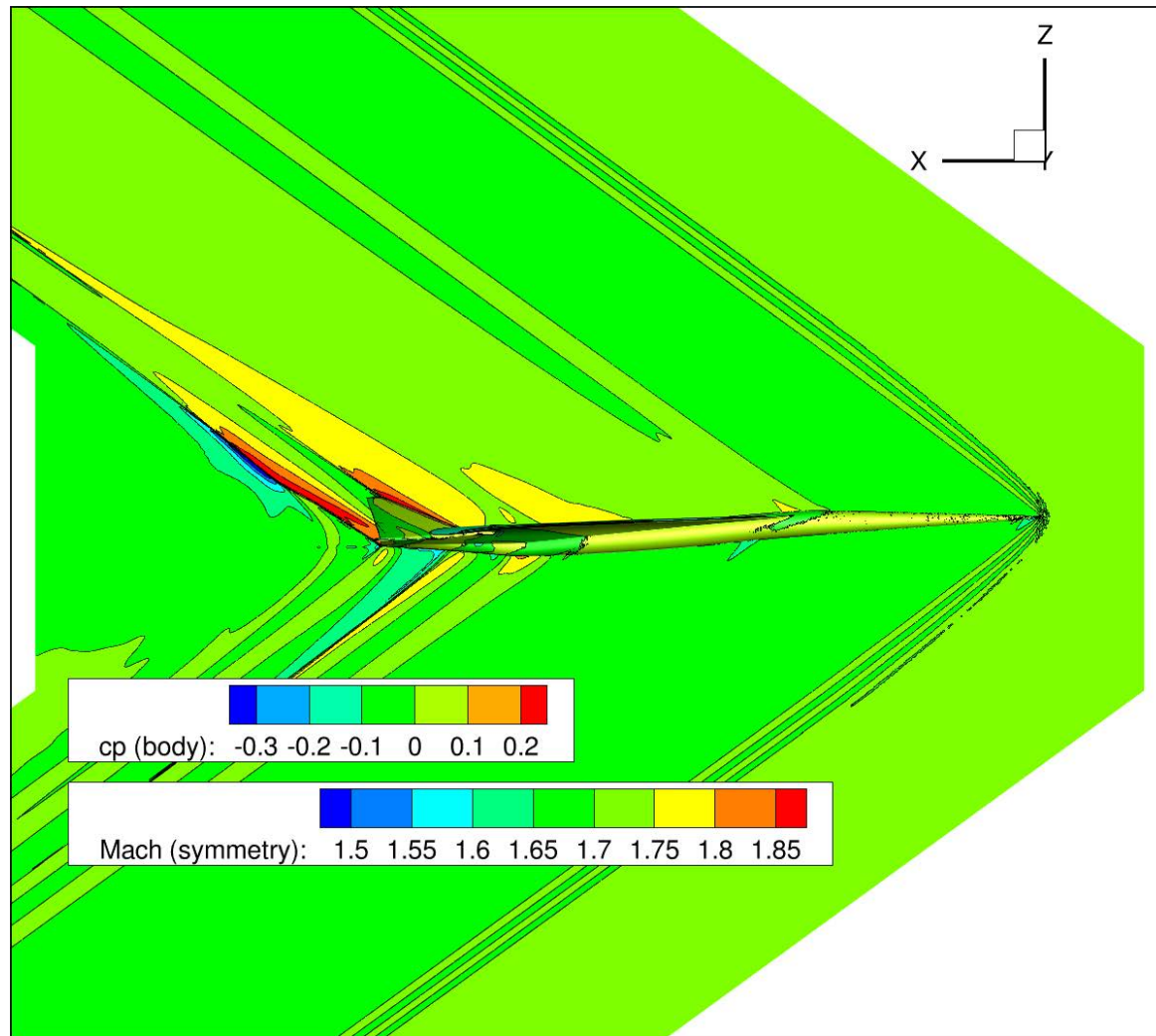
Inviscid, No Engines, Mach = 1.70, $\alpha = 2.25^\circ$



46.5 MGP, $C_L = 0.14343$, $C_D = 0.09251$

Sonic Boom Fine Solution

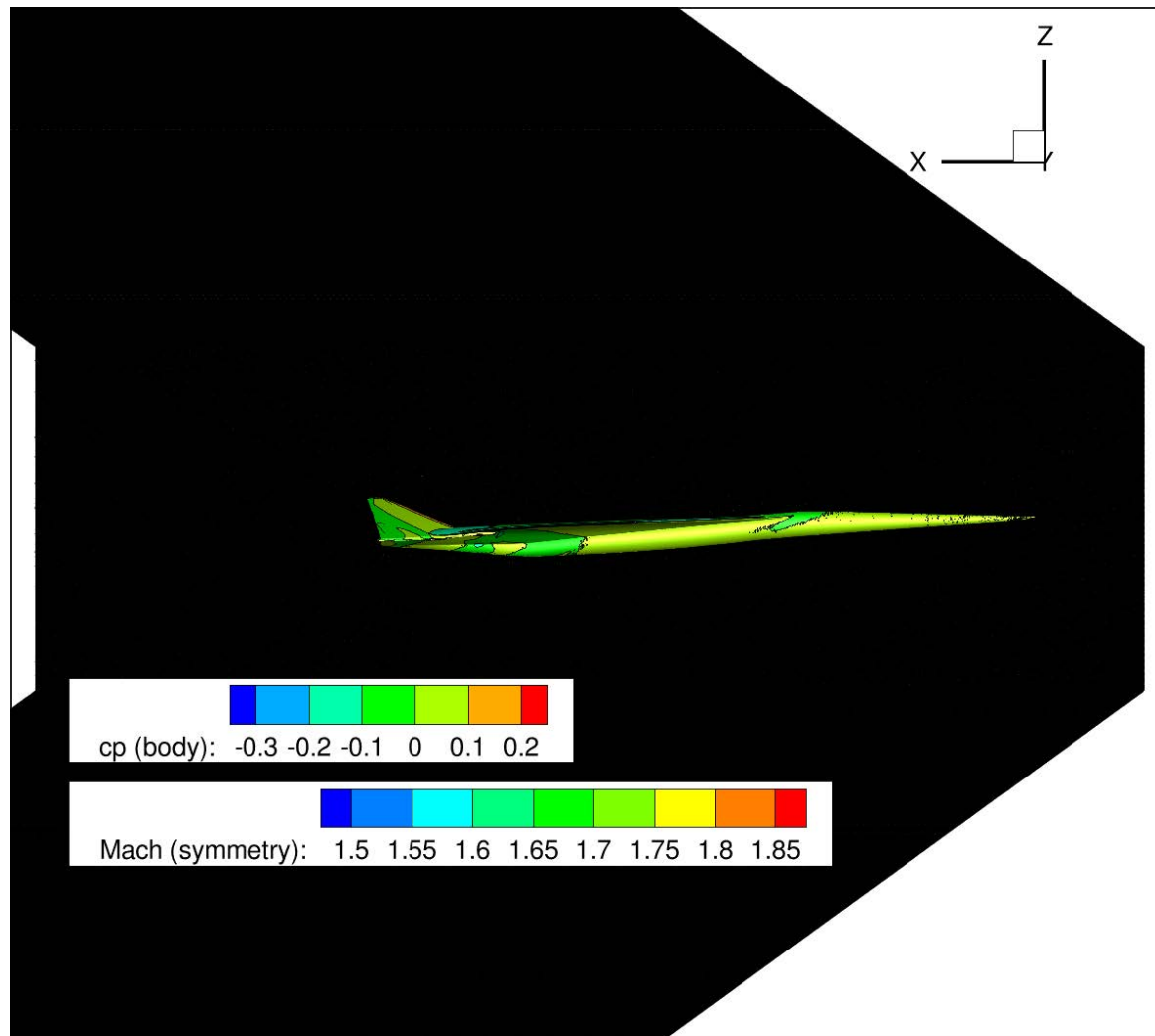
Inviscid, No Engines, Mach = 1.70, $\alpha = 2.25^\circ$



89.9 MGP, $C_L = 0.14342$, $C_D = 0.09256$

Sonic Boom Fine Solution with Grid

Inviscid, No Engines, Mach = 1.70, $\alpha = 2.25^\circ$



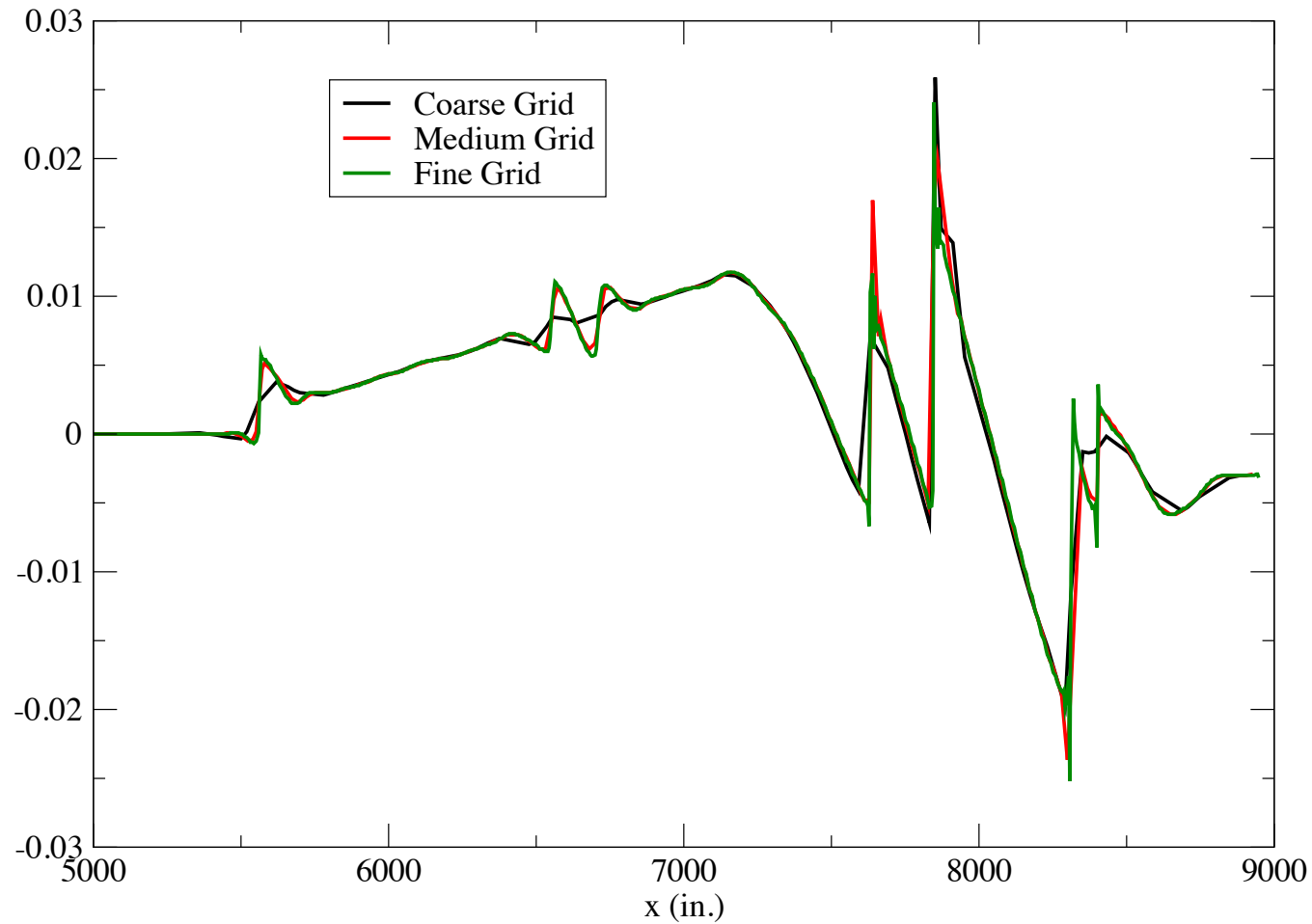
89.9 MGP, $C_L = 0.14342$, $C_D = 0.09256$

Sonic Boom Grid Resolution Study



Near-field Pressure Signature

No Engines, Undeformed, Mach = 1.7, Alpha = 2.25

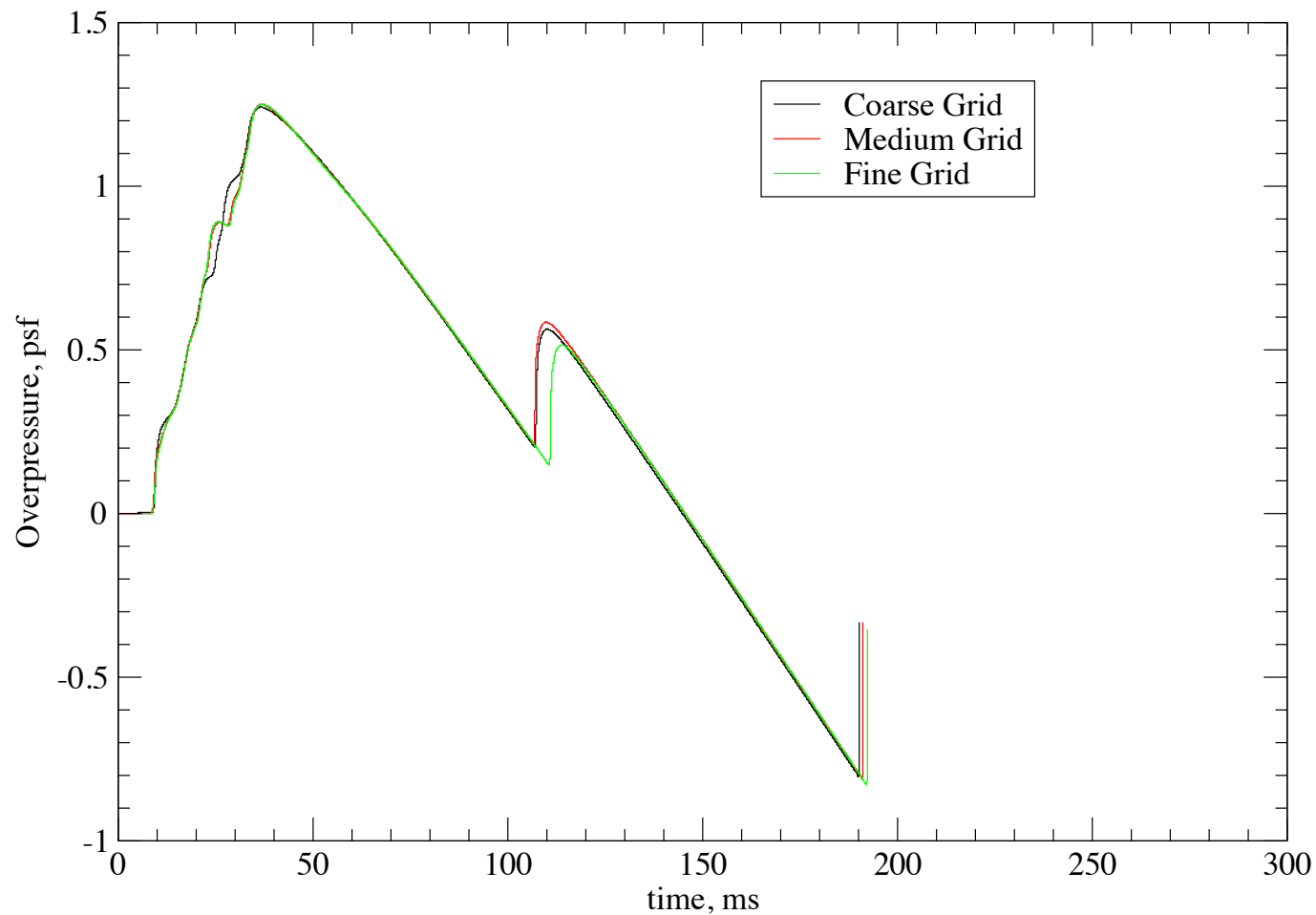


Sonic Boom Grid Resolution Study (cont.)



Ground Level Boom Signature

No Engines, Undeformed, Mach = 1.7, Alpha = 2.25

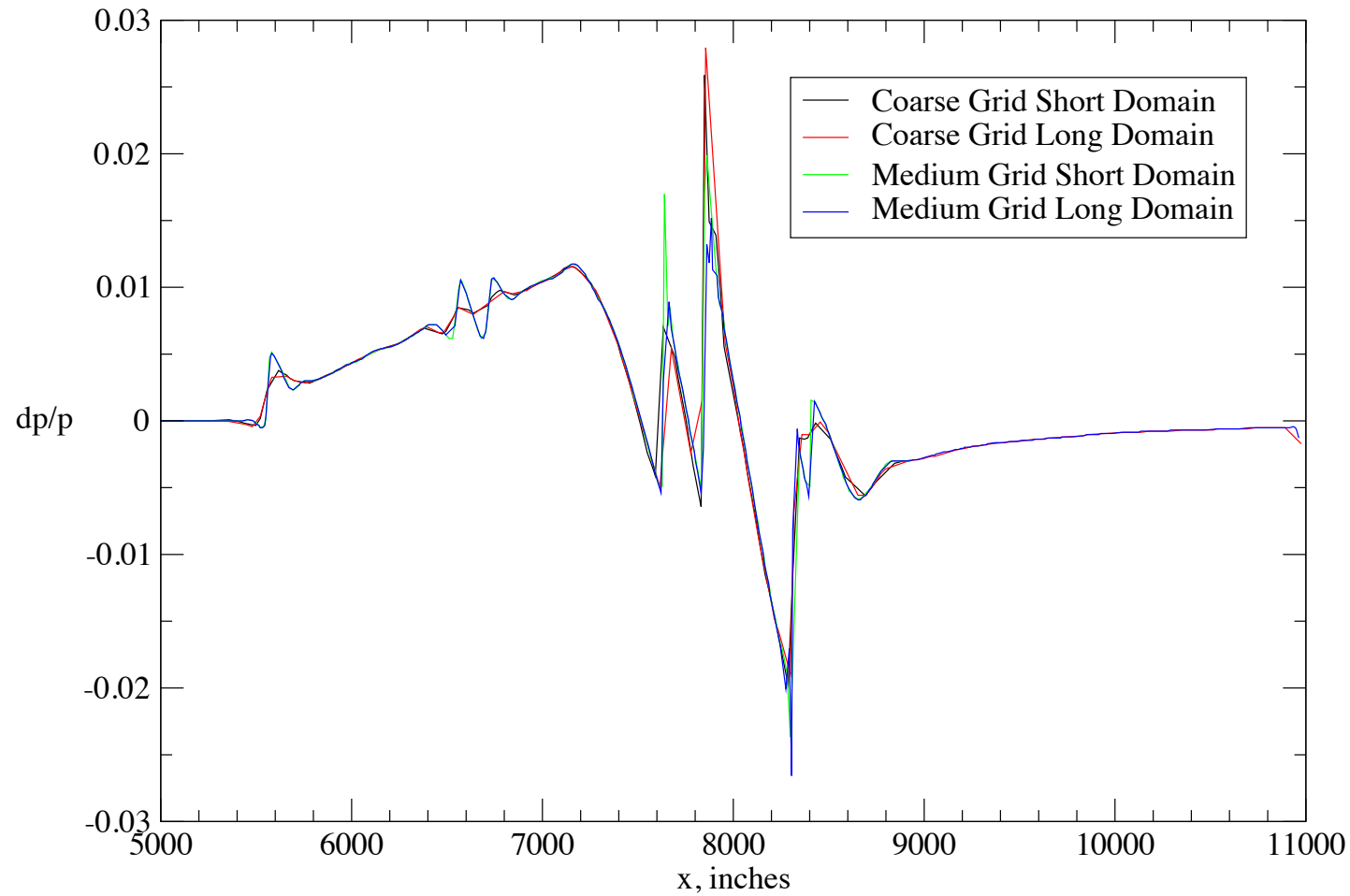


Sonic Boom Domain Size Study



Near-field Pressure Signature

No Engines, Undeformed, Mach = 1.7, Alpha = 2.25

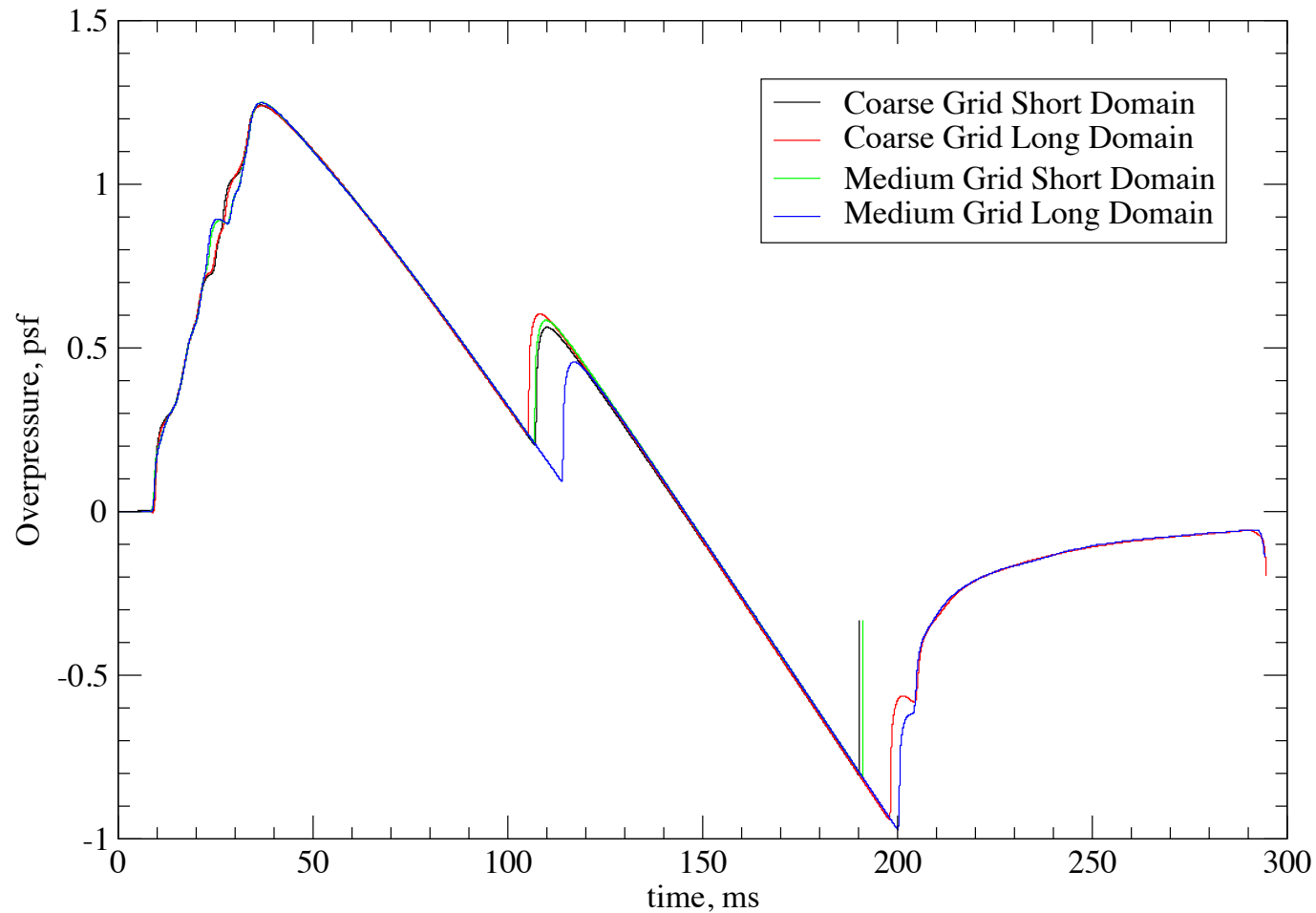


Sonic Boom Domain Size Study (cont.)



Ground Level Boom Signature

No Engines, Undeformed, Mach = 1.7, Alpha = 2.25

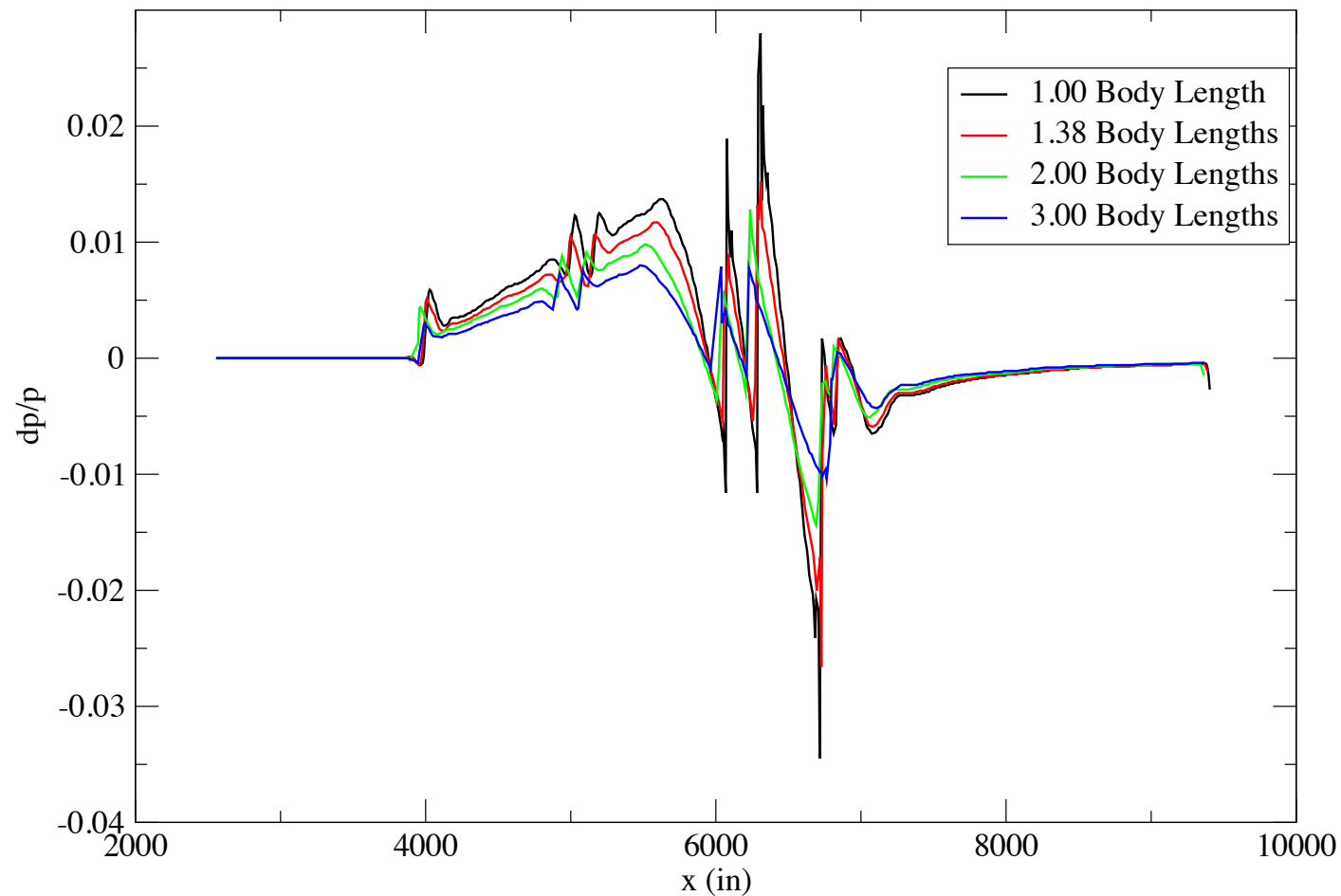


Sonic Boom Extraction Position Study



Near-field Pressure Signature

No Engines, Medium Grid, Undeformed, Mach = 1.7, Alpha = 2.25

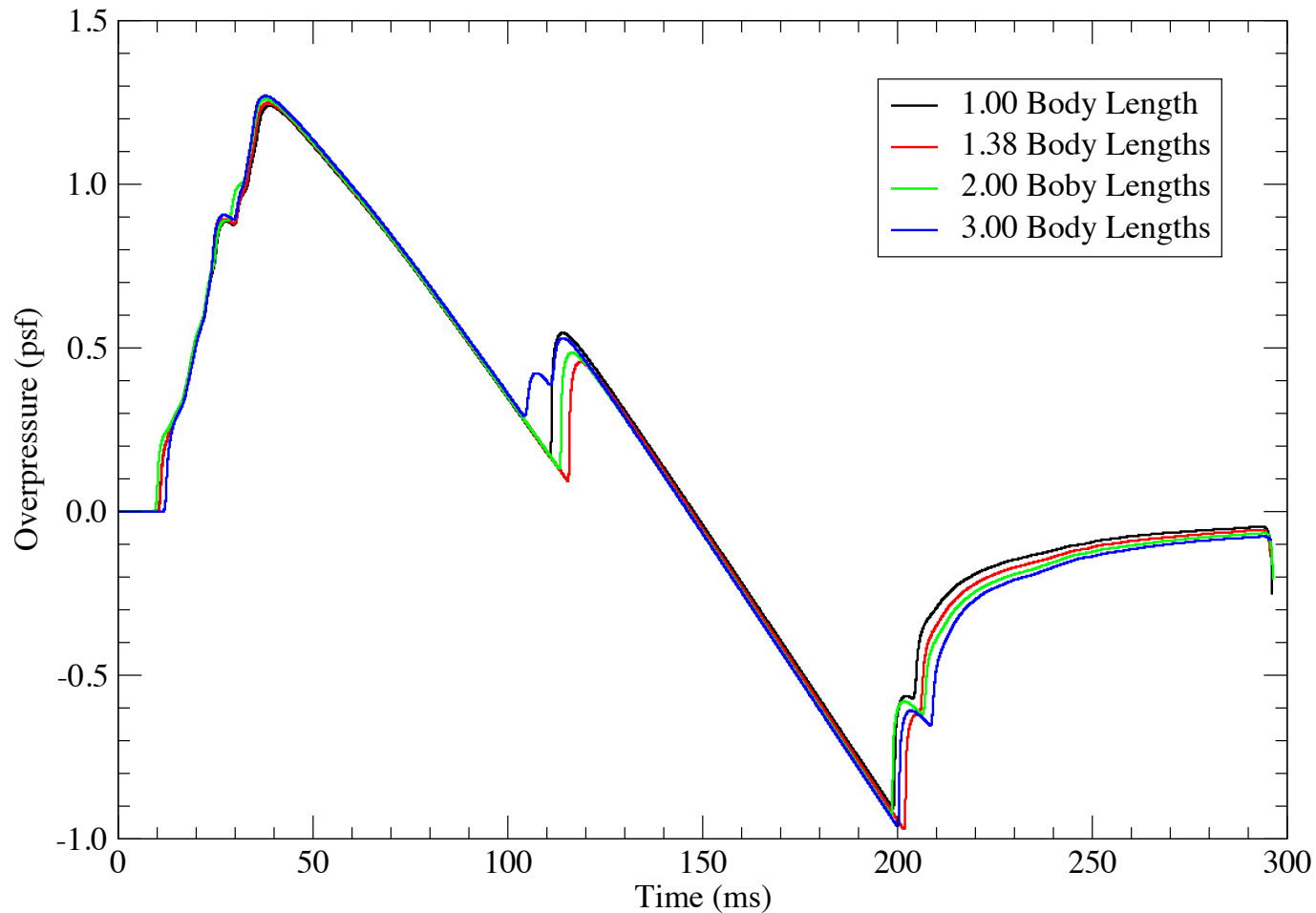


Sonic Boom Extraction Position Study (cont.)



Ground Level Boom Signature

No Engines, Medium Grid, Undeformed, Mach = 1.7, Alpha 2.25

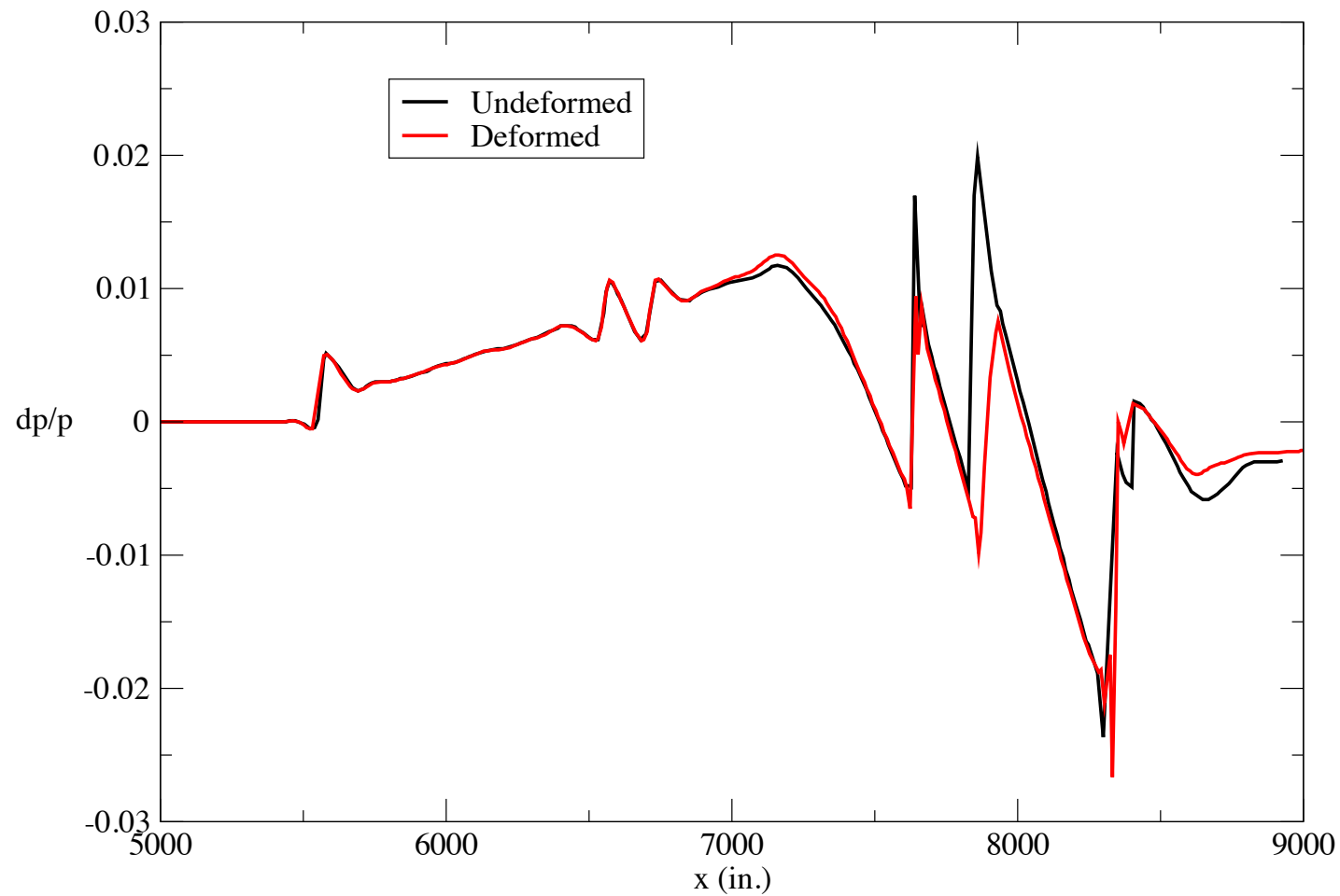


Sonic Boom Effect of Deflections Study



Near-field Pressure Signature

No Engines, Medium Grid, Mach = 1.7, Alpha = 2.25

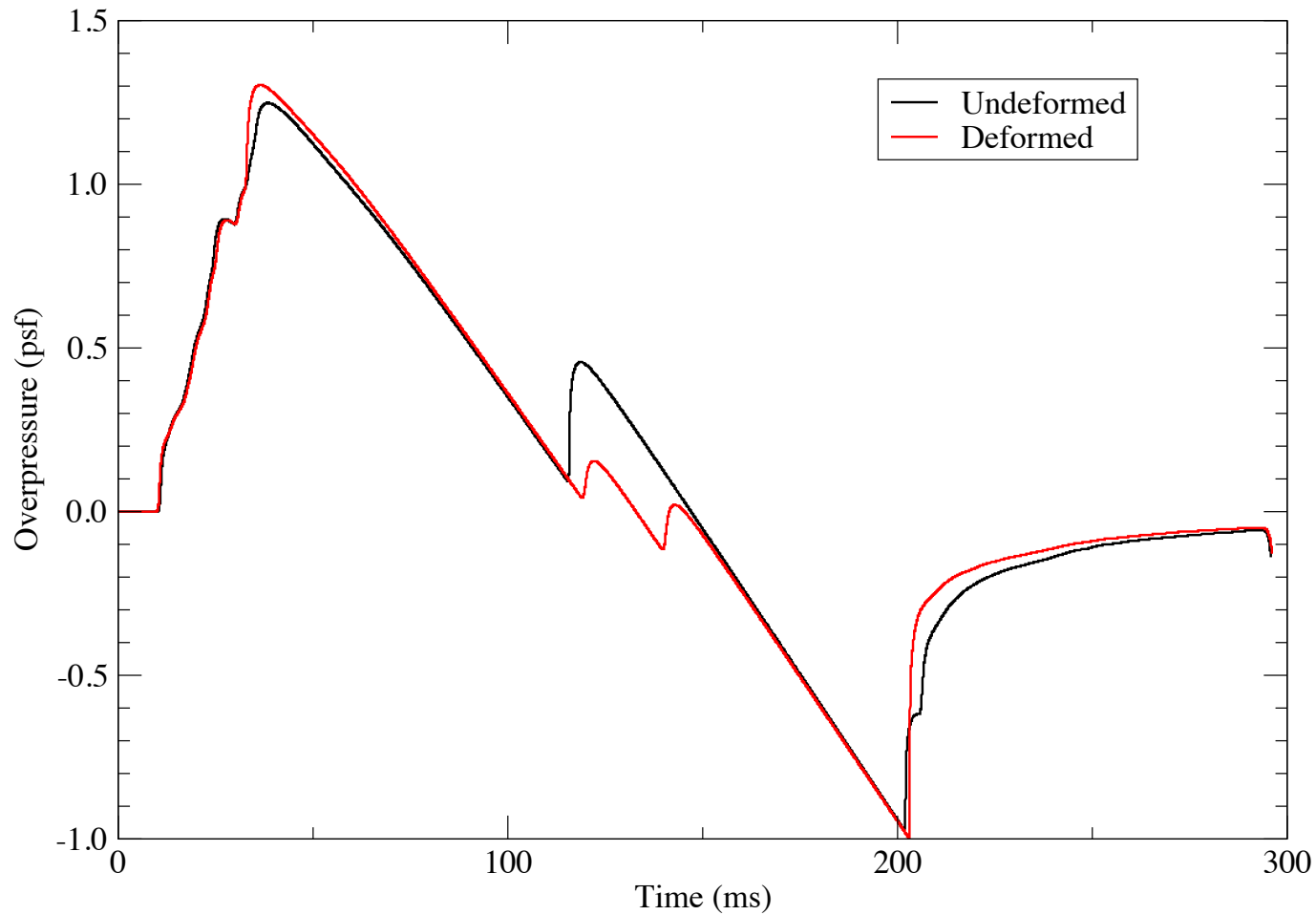


Sonic Boom Effect of Deflections Study (cont.)



Ground Level Boom Signature

Medium Grid, No Engines, Mach = 1.7, Alpha 2.25

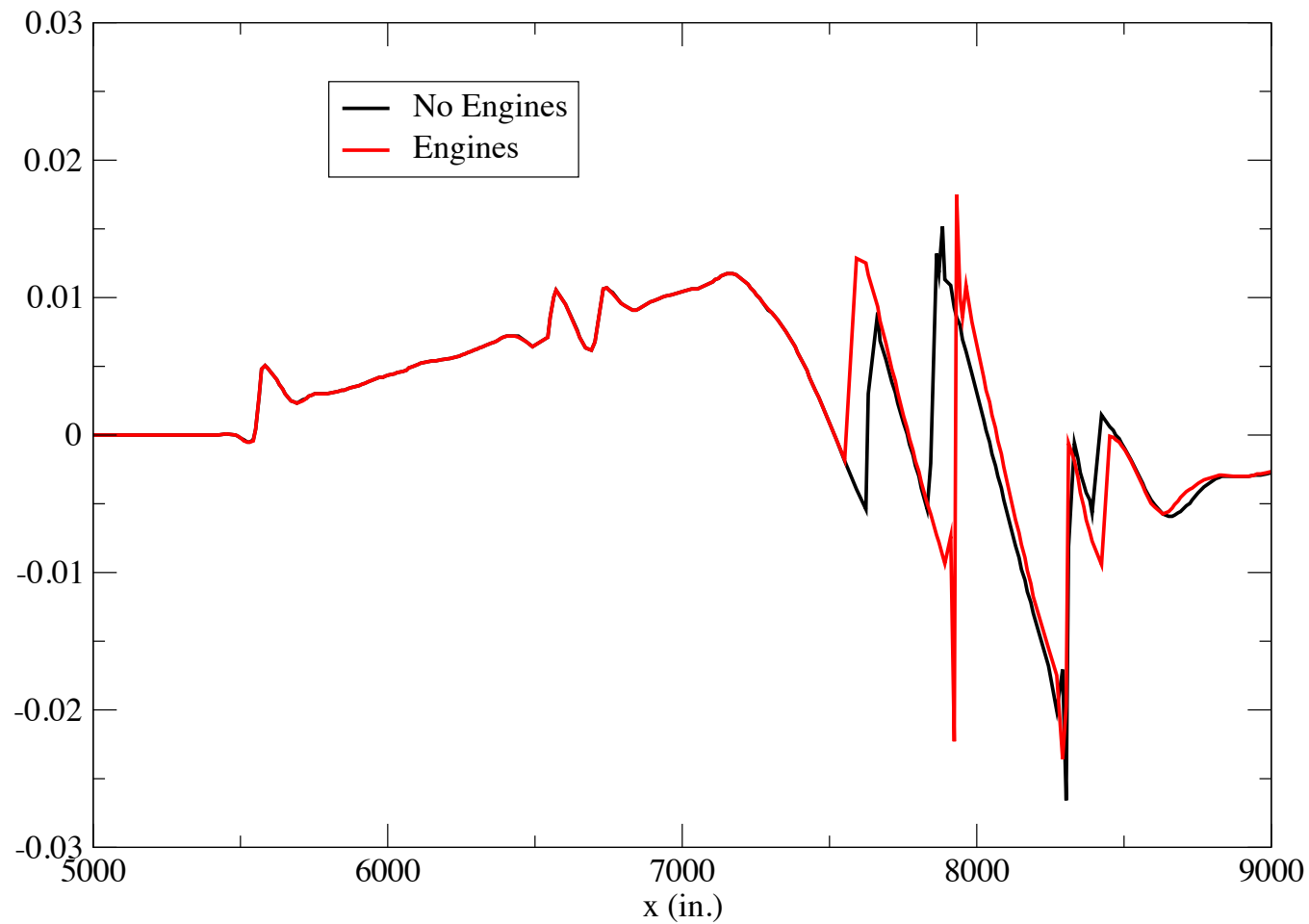


Sonic Boom Effect of Engines Study



Near-field Pressure Signature

Meduim Grid, Undeformed, Mach = 1.7, Alpha = 2.25

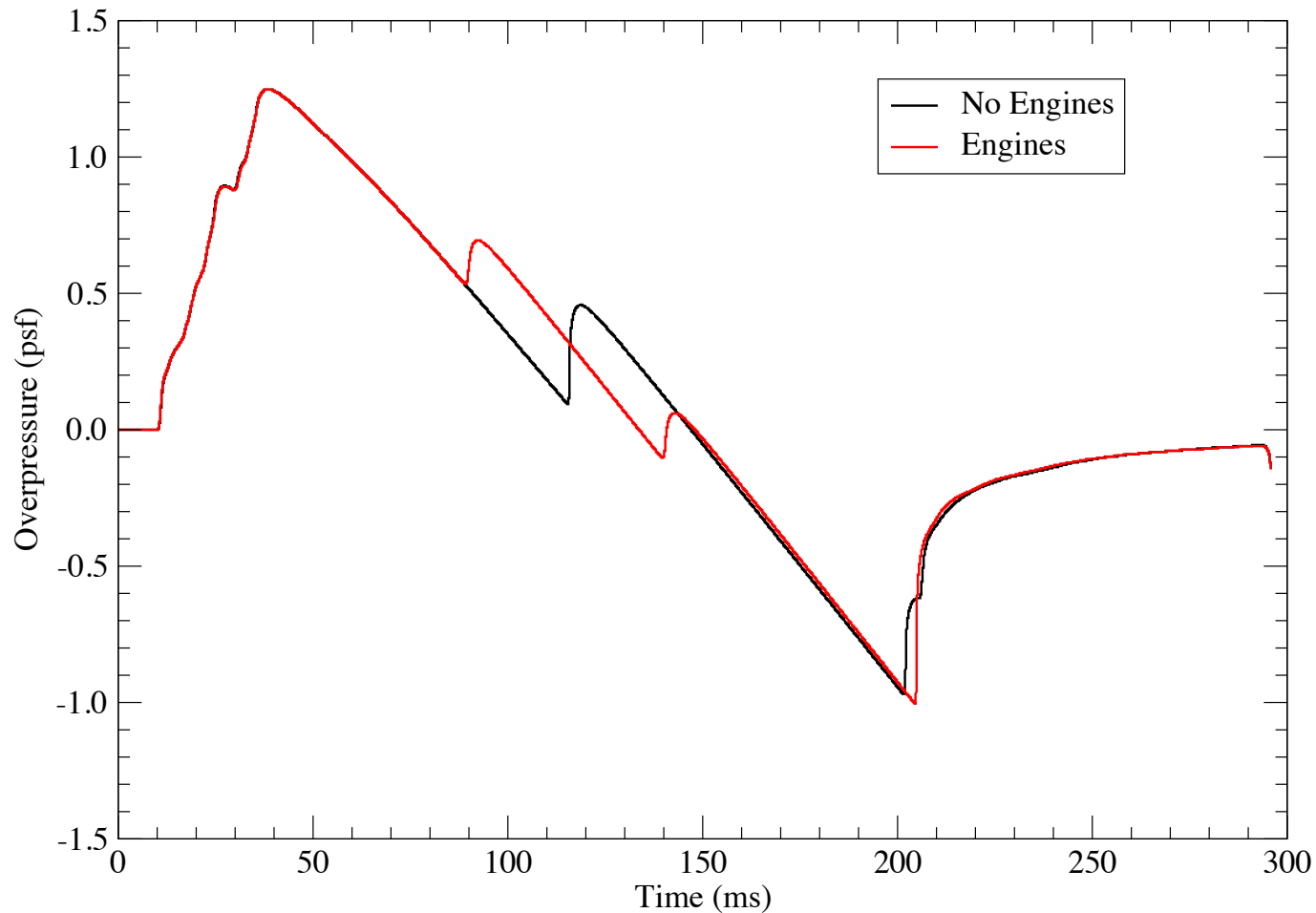


Sonic Boom Effect of Engines Study (cont.)



Ground Level Boom Signature

Medium Grid, Undeformed, Mach = 1.7, Alpha 2.25



Concluding Remarks



- Sonic boom signatures have been computed for the N+2 configuration
- Still a work in progress; much learning to be done
- Major questions to be answered
 - Exactly what is the configuration are we analyzing?
 - What is the best procedure for static aeroelastic computations?
- Future Work
 - Additional computations with engines
 - More realistic engines?
 - Viscous Calculations
- A good start has been made in the investigation of the aeroelastic effects on the sonic boom signature



Mark.D.Sanetrik@nasa.gov